

Claims:

1. An actuator having:

an actuator chamber containing a moveable actuator  
5 piston and an actuator rod connected to the actuator  
piston and retractably extendable from the actuator;

the actuator chamber and actuator piston defining an  
extend chamber and a retract chamber separated from the  
extend chamber by the actuator piston such that the  
10 actuator rod extends through the retract chamber;

a fluid supply means arranged to supply fluid  
simultaneously to both the extend and retract chamber at  
substantially the same pressure and to reversibly  
transfer said pressurised fluid between the extend and  
15 retract chambers of the actuator.

2. An actuator according to Claim 1 in which the fluid  
supply means is operable to control the mutual fluid  
pressure of the fluid supplied thereby to the extend and  
20 retract chambers to be sufficient to enable the actuator  
to support a load applied to the actuator in use.

3. An actuator according to Claim 1 or Claim 2 in which  
the fluid supply means is arranged to reversibly transfer  
25 said pressurised fluid between the extend and retract  
chambers of the actuator, and to separately and

independently reversibly transfer said pressurised fluid between the extend chamber and a pressurised fluid store means.

5        4. An actuator according to Claim 1 or Claim 2 or Claim 3 in which the fluid supply means is arranged to transfer between the extend and retract chambers volumes of pressurised fluid substantially equal to a change in the volume of the retract chamber.

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5. An actuator according to Claim 4 in which the fluid supply means is arranged to simultaneously transfer to and from the extend chamber volumes of pressurised fluid substantially equal to the change in the volume of the extend chamber less the concurrent change in the volume of the retract chamber.

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6. An actuator according to any preceding claim in which the fluid supply means includes a first fluid transfer means in fluid communication with the extend chamber and the retract chamber and arranged to transfer therebetween volumes of fluid substantially equal in magnitude to changes in the volume of the retract chamber resulting from movement of the actuator piston within the actuator chamber;

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and a second fluid transfer means in fluid communication with the extend chamber and operable to transfer to and from the extend chamber volumes of fluid substantially equal in magnitude to the difference  
5 between said changes in the volume of the retract chamber and concurrent changes in the volume of the extend chamber.

7. An actuator according to Claim 6 wherein the first  
10 fluid transfer means is a reversible first fluid pump, and the second transfer means is a reversible second fluid pump whereby the second pump is arranged to pump fluid at a volumetric rate determined according to the volumetric pump rate of the first pump.

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8. An actuator according to Claim 7 in which the actuator chamber, actuator piston and those parts of the actuator rod within the actuator chamber define a retract chamber of substantially annular volume, whereby the  
20 ratio of the concurrent volumetric pump rates of the second and first pumps is substantially equal to the ratio of: changes in the volume of those parts of the actuator rod within the retract chamber; and, the corresponding changes in the annular volume of the  
25 retract chamber.

9. An actuator according to any of preceding claims 6 to 8 in which the second fluid transfer means is in fluid communication with a fluid vessel and is arranged to transfer fluid from the extend chamber to the fluid vessel and vice versa, wherein the fluid vessel is arranged to hold fluid received thereby from the second fluid transfer means in a state sufficiently pressurised to generate a back-pressure upon the second fluid transfer means which partially resists the flow of fluid from the second fluid transfer means to the fluid vessel.

10. An actuator according to Claim 9 wherein the fluid vessel is a fluid conduit connecting the second fluid transfer means in fluid communication with, and terminating at, a hydraulic accumulator.

11. An actuator according to claim 9 or claim 10 wherein the second transfer means is a reversible fluid pump and said fluid vessel is arranged to generate said back-pressure being sufficient to urge the reversible fluid pump of the second transfer means to back-drive thereby to urge the pump to operate to pump fluid from the fluid vessel to the extend chamber.

12. An actuator according to any of proceeding

claims 9 to 11 wherein said fluid vessel is operable to be in fluid communication with said first fluid transfer means via said second fluid transfer means.

5        13.        An actuator according to any of claims 9 to 12 including a fluid supply operable to be in fluid communication with and to supply pressurised fluid to said fluid vessel, said first fluid transfer means, said second fluid transfer means, and said actuator chamber.

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14.        A method of actuation for use with an actuator having an actuator chamber containing a moveable actuator piston and an actuator rod connected to the actuator piston and retractably extendable from the actuator, the  
15        actuator chamber and actuator piston defining an extend chamber and a retract chamber separated from the extend chamber by the actuator piston such that the actuator rod extends through the retract chamber, the method including:

20        supplying fluid simultaneously to both the extend and retract chamber at substantially the same pressure and reversibly transferring said pressurised fluid between the extend and retract chambers of the actuator.

25        15.        A method according to Claim 14 including

controlling the mutual fluid pressure of the fluid supplied to the extend and retract chambers to be sufficient to enable the actuator to support a load applied to the actuator in use.

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16. A method according to Claim 14 or 15 including reversibly transferring said pressurised fluid between the extend and retract chambers of the actuator, and separately and independently reversibly transferring said  
10 pressurised fluid between the extend chamber and a pressurised fluid store means.

17. A method according to Claim 14, 15 or 16 including transferring between the extend and retract  
15 chambers volumes of pressurised fluid substantially equal to a change in the volume of the retract chamber.

18. A method according to Claim 17 including simultaneously transferring to and from the extend  
20 chamber volumes of pressurised fluid substantially equal to the change in the volume of the extend chamber less the concurrent change in the volume of the retract chamber.

25 19. A method according to any of Claims 14 to 18

including transferring between the extend chamber and the retract chamber volumes of fluid substantially equal in magnitude to changes in the volume of the retract chamber resulting from movement of the actuator piston within the  
5 actuator chamber;

transferring to and from the extend chamber volumes of fluid substantially equal in magnitude to the difference between said changes in the volume of the retract chamber and concurrent changes in the volume of  
10 the extend chamber.

20. A method of actuation according to Claim 19 wherein fluid is transferred between the extend chamber and the retract chamber by the reversible pumping thereof  
15 at a first volumetric pump rate, and fluid is transferred to and from the retract chamber by the reversible pumping thereof at a second volumetric pump rate determined according to the first volumetric pump rate.

20 21. A method of actuation according to Claim 20 in which the actuator chamber, actuator piston and those parts of the actuator rod within the actuator chamber define a retract chamber of substantially annular volume, whereby the ratio of the concurrent second and first  
25 volumetric pump rates is substantially equal to the ratio of: changes in the volume of those parts of the actuator

rod within the retract chamber; and, the corresponding changes in the annular volume of the retract chamber.

22. A method of actuation according to any of  
5 preceding claims 19 to 21 including holding fluid transferred from, or to be transferred to, the extend chamber in a state sufficiently pressurised to generate a back-pressure which partially resists the transfer of fluid from the extend chamber.

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23. A method of actuation according to claim 22 including providing a reversible fluid pump arranged to perform said transfer of fluid to and from the extend chamber by pumping said fluid, and generating said back-  
15 pressure to be sufficient to urge the reversible fluid pump to back-drive thereby to urge the pump to operate to pump said held fluid to the extend chamber.

24. A method of actuation according to any of  
20 proceeding claims 22 to 23 including holding said held fluid in fluid communication with said extend chamber and said retract chamber.

25. A method of actuation according to any of  
25 preceding claims 19 to 24 for use in providing simulated motion in a vehicle simulator machine.



26. A motion platform for a vehicle motion simulator machine including an actuator according to any of claims 1 to 13.

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27. A vehicle motion simulator including a motion platform according to Claim 26.

28. An actuator according to any of claims 1 to 13  
10 or 26 or 27 wherein the pressure of the pressurised fluid simultaneously supplied to extend and retract chambers is determined according to the load being experienced by the actuator.

15 29. An actuator according to any of claims 1 to 13 or 26 to 28 wherein the pressure of the pressurised fluid simultaneously supplied to extend and retract chambers is determined according to the position/extension of the actuator rod of the actuator.

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30. A method of actuation according to any of claims 14 to 25 including supplying the pressurised fluid simultaneously to extend and retract chambers at a fluid pressure determined according to the load being  
25 experienced by the actuator.

31. A method according to any of claims 14 to 25 or  
30 or 26 to 28 including supplying the pressurised fluid  
simultaneously supplied to extend and retract chambers at  
a fluid pressure determined according to the  
5 position/extension of the actuator rod of the actuator.

32. A method of actuation substantially as  
described in any one embodiment hereinbefore with  
reference to the accompanying drawings.

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33. An actuator substantially as described in any  
one embodiment hereinbefore with reference to the  
accompanying drawings.

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